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(54) GAS STREAM CLEANING SYSTEM

(71) We, BECKMAN INSTRUMENTS, INC., 2500 Harbor Boulevard, Fullerton, California, United States of America, a corporation organised and existing under the laws of the State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the separation of solids from gas streams containing solid particles.

Analysers of various types have been employed for analysing gases such as flue gases from boilers, blast furnaces, basic oxygen steel-producing furnaces, and cupolas and other dirty gas streams containing solid particles. Gas analysers available for gas analysis include infrared absorption type analysers for carbon monoxide, carbon dioxide, nitric oxide, and sulphur dioxide, gas chromatography column type analysers, chemiluminescence analysers for nitric oxide and oxides of nitrogen, and polarographic oxygen analyses, and for measurement of gases in dirty streams by such analyses in the past a filter element has been employed such as a silicon carbide or sintered metal filter element to filter the dirt. The dirt collects on this filter element, causing a pressure drop across the element and eventually causing the sample flow to the analyser to stop. This problem has been overcome to some extent by reverse flow cleaning the filter element, from within by dry air, for clearing the filter again. However, the filter element is not quite as clean as before because particles are still embedded in the filter element material. Consequently, after a period of time the filter pores become completely plugged and cannot be unplugged by repeated blowbacks and a new element becomes necessary for continuing the analysis.

It is an object of the invention to achieve improved removal of solids from a gas stream.

According to the present invention there is provided a method of separating solids from a gas stream containing solid particles, which method comprises the steps of drawing gas from the stream to form an inlet stream flowing in a first linear direction through a separation zone to clean the inlet stream, recirculating a portion of the cleaned inlet stream to the separation zone to form a reflux stream flowing in the reverse linear direction, and discharging the reflux stream concentrically with respect to the inlet stream and against the uncleaned inlet stream so as to form a dynamic screen thereby removing solid particles.

Further according to the present invention there is provided apparatus for carrying out the method according to the preceding paragraph comprising an inlet proble for receiving the inlet stream of gas, means for moving the inlet stream in a first direction through the probe, gas return means for returning a portion of the cleaned inlet stream to a discharge orifice, the discharge orifice being coaxial with respect to the inlet probe, and connected to the gas return means so as to direct cleaned gas in a direction opposite to the first direction against the inlet stream.

When the method of the present invention is to be employed in conjunction with the analysis of a sample of flue gas or the like a probe is mounted in a flue or stack. The suction side of a fan or pump is connected to the probe through tubing, and the output port of the pump is connected through suitable tubing to a gas analyser. The pump may be connected to a product line if the cleaned gas is to be utilised directly for some process purpose rather than being analysed.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a first embodiment of the invention;

Fig. 2 is a schematic diagram of a second embodiment of the invention;

Fig. 3 illustrates a form of construction which may be employed in carrying out the

invention represented by the first embodiment and illustrating a form of installation which may be employed; and

Fig. 4 is a schematic diagram of a further embodiment of the invention arranged as a system for cleaning flue gases which are being discharged.

Like reference characters are utilised throughout the drawings to designate like parts.

In Fig. 1, an inlet or sample probe 12 extends into a flue or stack 11, the probe 12 having a casing or shell 10 which is connected through small diameter tubing 13 to the suction side of a centrifugal pump 14. The pressure side of the centrifugal pump 14 is connected by lengths of tubing 15 and 16 to a throttling valve 18 in series with a flowmeter 19 and a gas analyser 17. A portion of the output from the pump 14 through the tube 15 is recirculated into the probe 12 and for this purpose a reflux tube 21 is connected at the junction of the outlet tubes 15 and 16 terminating in a discharge orifice 22 in the interior of the shell 10 of the probe 12.

In the probe 12, the gas drawn by the suction side of the pump 14 travels in a concentric path parallel to the axis of the casing or shell 10, represented by arrows 23 into the tubing 13 and the pump 14. There is a reflux gas stream represented by arrows 24 in the reflux tube 21 which is discharged at the orifice 22. As shown, the gas stream in the tube 21 moves parallel to the axis thereof which is concentric with the axis of the probe shell 10 and on discharge spreads or diverges in the direction of arrows 25 against the dirty gas entering the probe 12 along the arrows 26.

The reflux flow in the portion of the sample probe 12 at the arrows 25 forms a scrubbing stream acting as a dynamic screen, causing the solid particles to be removed.

The embodiment is not dependent upon the use of particular sizes of tubing or flow capacities. For the purpose of illustration, in the case of an installation with a pump 14 drawing a sample of 17,000 cubic centimetres per minute, satisfactory results have been obtained with a reflux flow constituting a large proportion of the sample flow of the order of 88% of the output of the pump, for example 15,000 cubic centimetres per minute flowing through the reflux tube 21 and from the discharge orifice 22. In the specific embodiment illustrated and for the gas flows mentioned, satisfactory results have been obtained when the inside diameter of the probe 12 is approximately twice the outside diameter of the discharge orifice 22, for example with a discharge orifice 22 one quarter inch in outside diameter and a shell 10 of the gas probe 12 one half inch in inside diameter. The discharge orifice 22 of the reflux tube was recessed about ten inches from the inlet end of the sample probe 12 i.e. about twenty times the inside diameter of the probe 12.

It will be understood that variations in the dimensions may be made where different rates of flow are involved and the apparatus may also be employed where the probe 12 receives the entire flow of gas from a source to be utilised subsequently in a process and the pump 14 delivers gas through the tube 16 and elements 18 and 19 to apparatus in which the process is to be carried out instead of to an analyser 17.

Although in the arrangement of Fig. 1 a sample probe 12 has been employed with an internal reflux discharge orifice 22, for certain purposes, an alternative arrangement may be emloyed as illustrated in Fig. 2 in which there is a concentric outer reflux tube 28 with an open discharge orifice 29 which is concentric with and surrounds an inlet sample probe 31 connected through tubing 32 to the suction side of the pump 14 with the reflux tubing 21 being connected to the concentric larger diameter reflux tube 28. In this case the reflux stream converges inward along arrows 25′ instead of diverging outward and discharge thereby being projected against the incoming stream. It will be noted that the annular space between the inlet probe and the reflux tube is unobstructed to permit free stream flow.

As shown in Fig. 3, the probe 12 is preferably mounted with its axis horizontal and the axis of the reflux tubing 21 is likewise horizontal so that the reflux stream may travel parallel to the axis of the tubes 21 and 12 until it issues from the discharge orifice 22. When the sample is to be taken from a stack of a boiler or the like the probe 12 is inserted through the stack wall 30 so as to extend approximately 40 to 50% across the width or diameter of the stack. The probe is usually inserted at least three feet into the stack. In the case of a typical stack of 15 to 25 feet diameter the probe would be of sufficient length to extend from 7 to 10 feet, for example, into the stack. The arrangement permits continuous monitoring of the flue gases in the stack. Used with boiler stacks, the particulate matter to be excluded includes such solid particles as soot and fly ash and acid mists. Where the stack gases from other processes are to be monitored, the particulate matter may include such solid particles as catalyst residues, magnesium oxide, and possibly certain types of mists such as sulfuric acid mist.

The probe 12 is preferably composed of stainless steel.

As illustrated in Fig. 3, the reflux tube 21 may be mounted within the probe tube 12 by utilising a standard pipe T fitting 33 with the probe 12 threaded into one end, the pipe 13

threaded into the lateral fitting and a reducer plug fitting 34 threaded into the T fitting 33 opposite the connection of the probe 12. The plug 34 is arranged to receive the quarter inch outside diameter tubing 21 so as to extend through the T fitting 33 and into the probe 12 along the interior thereof as shown. The connection of the reflux tube 21 to the outlet tubing 15 and 16 may be made by means of a conventional T fitting 35 and a connecting pipe 36 with suitable means for reducing the diameter for connection to the reflux tube 21. For example by means of a reducing elbow 37.

Referring again to Fig. 1, the control of the relationship between the volume of flow in the piping 15 and 16 and in the reflux tube 21 is accomplished by the capacity of the blower 14, the valve 18 and the volume of sample withdrawn for the analyser 17. Where a flow of 2,000 cubic centimtres per minute is desired through the tube 16 and in the analyser 17, a blower or pump 14 is selected having a capacity of 17,000 cubic centimetres per minute and the throttling valve 18 is adjusted to reduce the output through the valve, the pipe 16 and into the analyser 17 to 2,000 cubic centimetres per minute of sample or product. Accordingly, 15,000 cubic centimetres per minute are returned through the reflux tube 21 and projected from the orifice 22 against the incoming stream of sample to be cleaned and analysed. The force of the reflux stream carries the particulate matter back into the stack where it either rises from the stack with the rising stream or falls to the bottom of the stack.

In the illustrative embodiment of Fig. 2 for a sample stream of 2,000 cubic centimetres per minute and an inlet to the sample probe of 17,000 cubic centimetres per minute, the inside diameter of the outer tube 28 of the sample probe is preferably three eighths inches and the outer diameter of the tubing 32 is one fourth inch. There is a recess or set back of the inlet probe 31 from the discharge end 29 of the outer tube 28 of approximately one-half inch.

In case a particulate cleaning system of the type described but of larger dimensions is employed as illustrated in Fig. 4 for removing solid particles from the entire effluent of dirty or particulate-laden gases from a boiler 41 or other sources of dirty or particulate laden gases as from various processes, the pump 41 is selected to have a capacity of about twelve times the air flow desired for the boiler 41; and the diameters of the probe duct 12, the reflux tube 21 and tubes 15 and 16 ar selected accordingly.

In conventional boiler installations requiring the removal of particulate matter from exhaust gases, suitable devices such as an electrostatic precipitator 42 or a wet chemical scrubber 43 are interposed in the flue from the boiler 41 to the stack 11. The use of the dynamic solid matter screen constructed in accordance with the invention reduces the size of the electrostatic precipitator 42 or the wet scrubber 43.

In the operation of the apparatus of Fig. 4, the particulate matter driven back into the boiler 41 tends to fall back toward the fire pot 44 and to be consumed before being picked up agan by the flow of exhaust gases, except for unconsumable material which may ultimately require removal by mechanical means.

WHAT WE CLAIM IS:—

1. A method of separating solids from a gas stream containing solid particles, which method comprises the steps of drawing gas from the stream to form an inlet stream flowing in a first direction through a separation zone to clean the inlet stream, recirculating a portion of the cleaned inlet stream to the separation zone to form a reflux stream flowing in the reverse linear direction, and discharging the reflux stream concentrically with respect to the inlet stream and against the uncleaned inlet stream so as to form a dynamic screen thereby removing solid particles.

2. The method as claimed in claim, wherein gas is continuously drawn to form the inlet stream and the reflux stream is continuously discharged.

3. The method as claimed in claim 1, wherein a major portion of the cleaned inlet stream is formed into the reflux stream.

4. The method as claimed in claim 3, wherein the volume of gas in the reflux stram is of the order of 88% of the volume of gas in the inlet stream flowing in the first linear direction.

5. The method as claimed in claim 1, wherein the volume of gas remaining in the cleaned inlet stream after recirculating said portion thereof is adjusted in order to adjust the proportion of the reflux stream to the inlet stream.

6. The method as claimed in claim 1, wherein the reflux stream is narrower in cross-section than the uncleaned inlet stream and is discharged centrally against the uncleaned inlet stream.

7. The method as claimed in claim 1, wherein the reflux stream has an annular cross-section in a portion of the separation zone and the inlet stream to be cleaned is drawn through the centre of the reflux stream.

8. The method as claimed in claim 1, including the further step of directing separated solid particles to a selected location.

9. A method of separating solids from a gas stream containing solid particles substantially as hereinbefore described with

reference to the accompanying drawings.

10. Apparatus for carrying out the method according to claim 1, comprising an inlet probe for receiving the inlet stream of gas, means for moving the inlet stream in a first direction through the probe, gas return means for returning a portion of the cleaned inlet stream to a discharge orifice, the discharge orifice being coaxial with respect to the inlet probe and connected to the gas return means so as to direct cleaned gas in a direction opposite to the first direction against the inlet stream.

11. Apparatus as claimed in claim 10, including a gas outlet line, and wherein the gas moving means comprises a pump with a suction side connected to the inlet probe and a pressure side connected to the outlet line, the outlet line having a double branch connection to one branch of which said gas return means is connected.

12. Apparatus as claimed in claim 10, wherein the inlet probe is of greater diameter than the discharge orifice and the discharge orifice is mounted within the inlet probe.

13. Apparatus as claimed in claim 12 wherein the inlet probe has an inlet end and the discharge orifice is set back from the inlet end of the inlet probe.

14. Apparatus as claimed in claim 13, wherein the set back exceeds the diameter of the inlet probe.

15. Apparatus as claimed in claim 11, wherein the other branch of said branch connection is connected to path restricting means of sufficient size to cause a major portion of the output from the pump to flow back through the gas return means.

16. Apparatus as claimed in claim 15, wherein the path retricting means is such as to cause of the order of 88% of the output from the pump to flow back through the gas return means.

17. Apparatus as claimed in claim 10, wherein the discharge orifice is of greater diameter than the inlet probe, the inlet probe being mounted within the gas return means.

18. Apparatus as claimed in claim 10, in combination with a wet chemical scrubber connected to receive the cleaned gas.

19. Apparatus as claimed in claim 12, wherein the inside diameter of the probe is approximately twice the outside diameter of the discharge orifice.

20. Apparatus as claimed in claim 19 wherein the inlet probe has an inlet end and the discharge orifice is set back from the inlet end of the probe about twenty times the inside diameter of the probe.

21. Apparatus as claimed in claim 10, including means connected to receive the cleaned gas and for subjecting the cleaned gas to further treatment.

22. Apparatus as claimed in claim 10 wherein means are provided in conjunction with the inlet probe for collecting solid particles driven therefrom.

23. Apparatus as claimed in claim 10, and substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

24. Apparatus as claimed in claim 10, and substantially as hereinbefore described with reference to Fig. 2 of the accompanying drawings.

25. Apparatus as claimed in claim 10, and substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

26. Apparatus as claimed in claim 10, and substantially as hereinbefore described with reference to Fig. 4 of the accompanying drawings.

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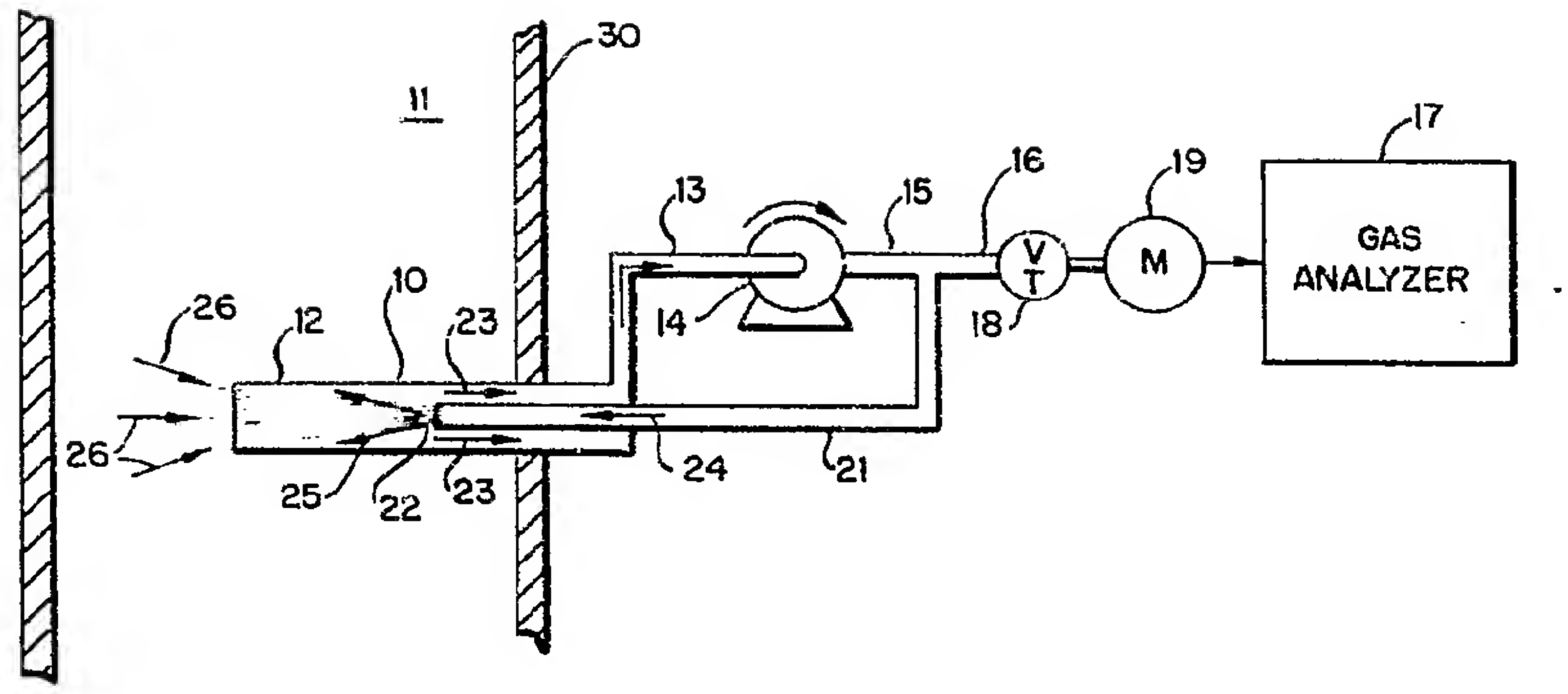
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FIG. 1

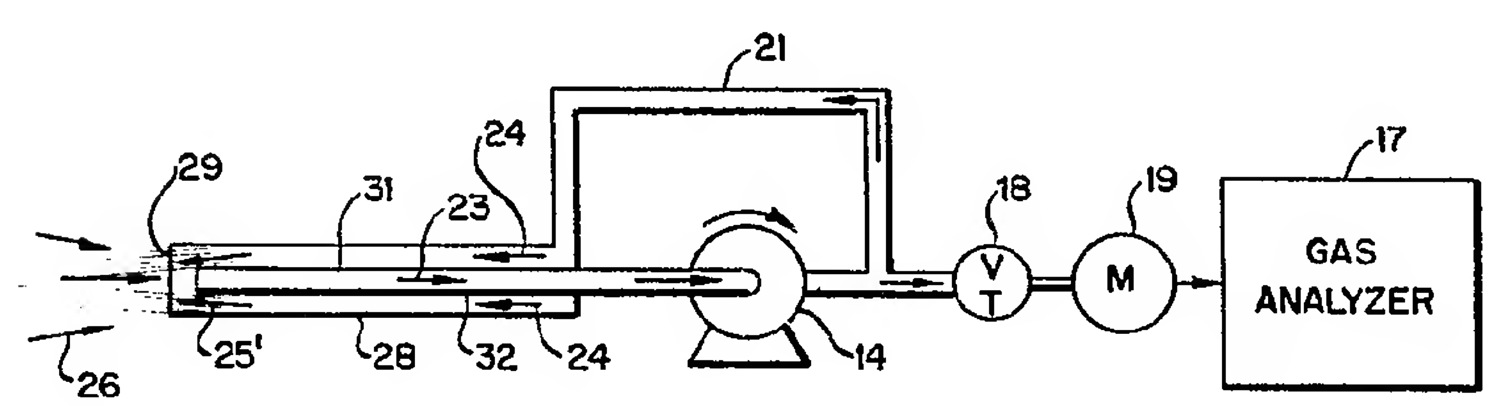
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FIG. 2

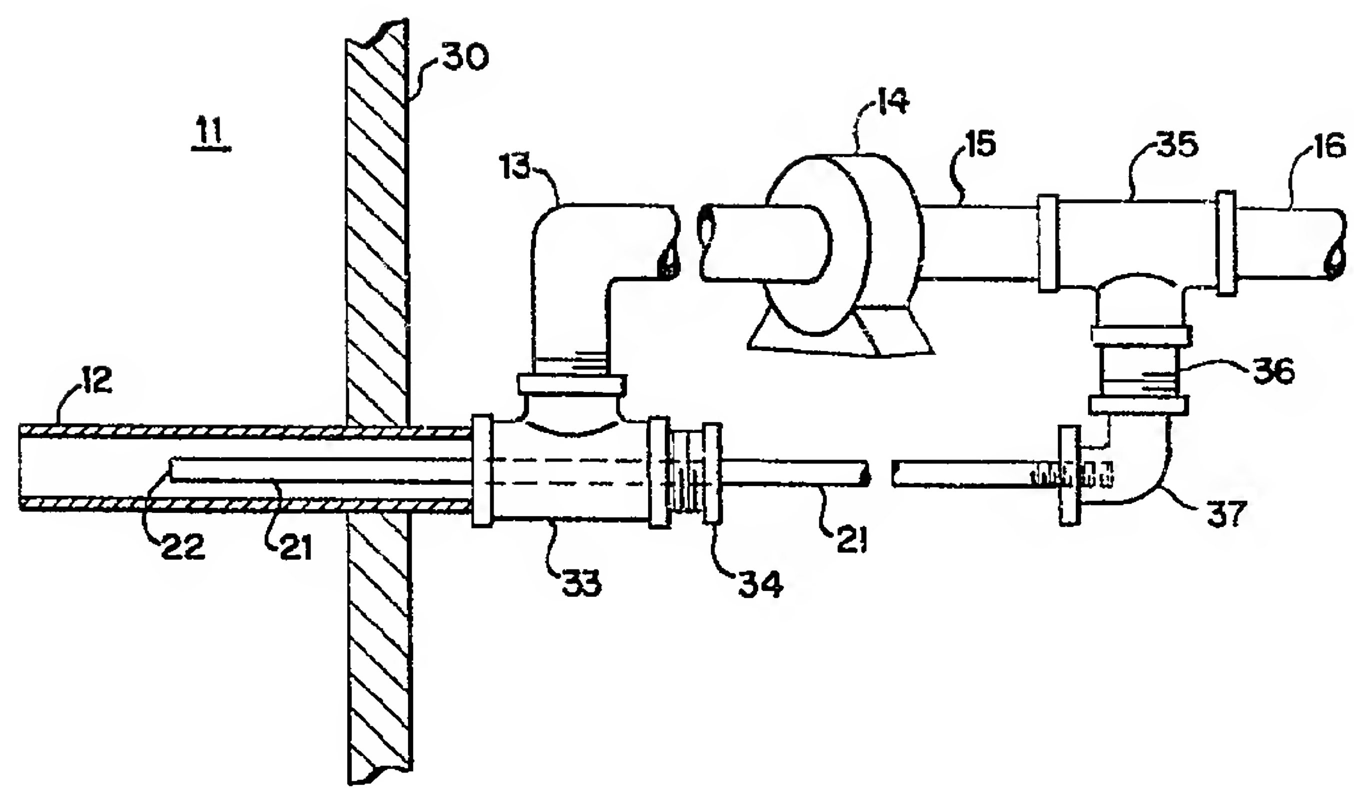
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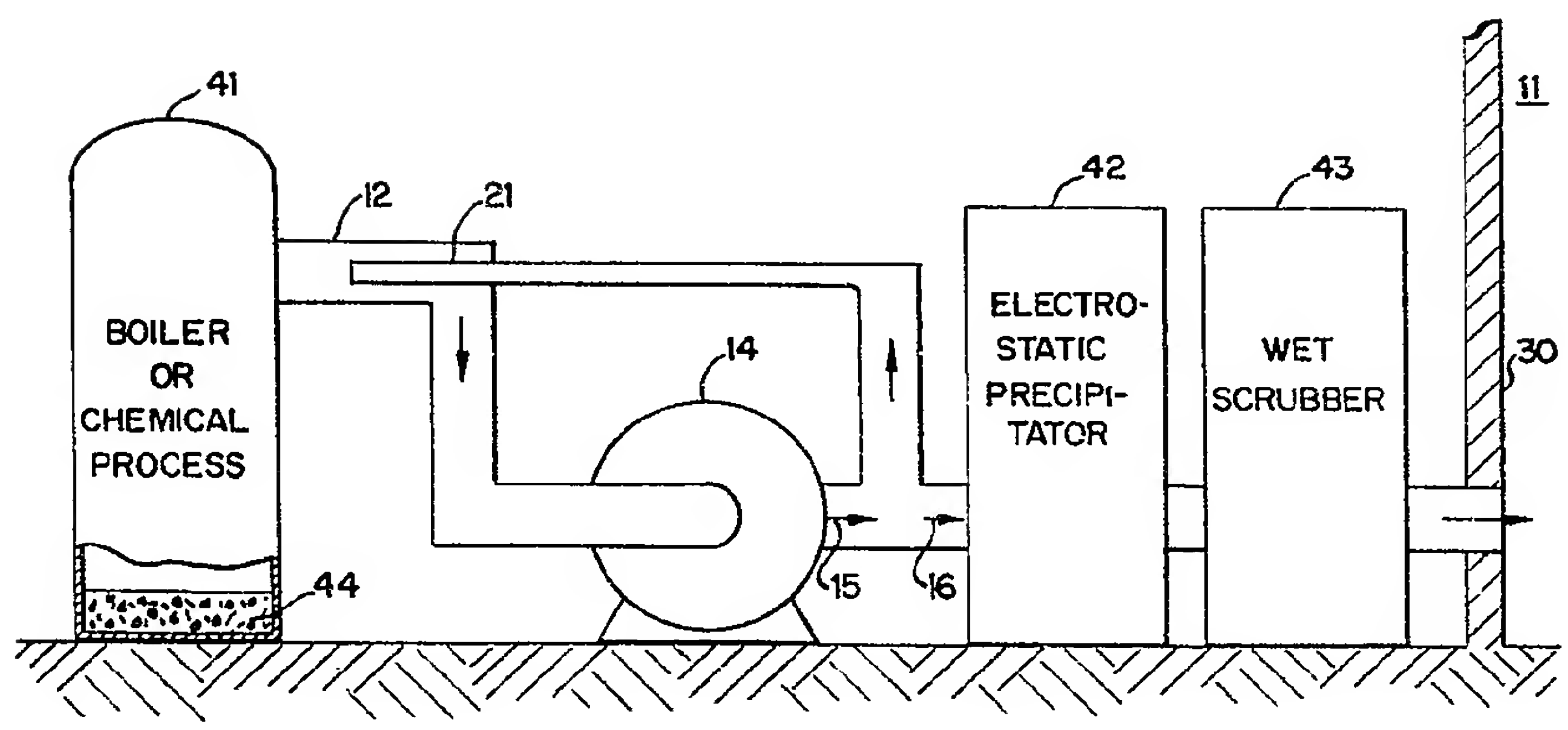
FIG. 3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BOILER
OR
CHEMICAL
PROCESS
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ELECTRO-
STATIC
PRECIPI-
TATOR
WET
SCRUBBER
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FIG. 4